ABRASION-RESISTANT SURFACE FINISHES ON METAL ENCLOSURES

FIELD

[0001] The described embodiments relate to abrasion-resistant coatings and methods for forming the same. The abrasion-resistant coatings can include a hard outer layer that resists abrasion, and an intermediate oxide layer that resists deformation upon impact and provides support for the hard outer layer.

BACKGROUND

[0002] Portable computing devices, such as mobile telephones, tablet computers, and laptop computers, come into contact with a wide range of hard and abrasive materials during normal use. Furthermore, the computing devices may be dropped and subject to impacts or abrasive wear from hard counter-materials. If the enclosures of the computing devices are not adequately protected, the enclosures can develop scratches, gouges and other defects that detract from the cosmetic appeal of the enclosures. If the enclosures include anodized metal portions, the scratches, gouges and defects may break through the protective anodic film and allow contaminants to corrode of the underlying metal. What are needed therefore are improved coatings for metallic surfaces.

SUMMARY

[0003] This paper describes various embodiments that relate to abrasion-resistant coatings useful for coating surfaces of consumer products, such as consumer electronic devices. In particular embodiments, the abrasion-resistant coatings include a porous oxide layer that provides structural support for an overlying hard layer formed of a highly abrasion-resistant material.

[0004] According to one embodiment, a housing for an electronic device is described. The housing includes a metal portion defining a cavity suitable for carrying internal electronic components. The housing also includes an abrasion-resistant coating disposed on a metal surface of the metal portion. The abrasion-resistant coating includes a hard layer characterized as having a first hardness. The abrasion-resistant coating also includes an intermediate layer grown from the metal portion and overlaid by the hard layer. The intermediate layer is composed of a porous oxide and is characterized as having a second hardness, wherein the first hardness is greater than the second hardness.

[0005] According to another embodiment, a part is described. The part includes a metal substrate and an abrasion-resistant coating disposed on the metal substrate. The abrasion-resistant coating includes an external layer composed of a diamond-like carbon material. The abrasion-resistant coating also includes an intermediate layer between the external layer and the metal substrate. The intermediate layer is composed of a porous oxide.

[0006] According to a further embodiment, a method of forming an abrasion-resistant coating on a housing for an electronic device is described. The housing has a metal portion defining a cavity suitable for carrying internal electronic components. The method includes converting a portion of the metal portion to a porous oxide layer. The method also includes depositing a hard layer on the porous oxide layer, wherein the hard layer is characterized as having a greater hardness than the porous oxide layer.

[0007] These and other embodiments will be described in detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The disclosure will be readily understood by the following detailed description in conjunction with the accompanying drawings, wherein like reference numerals designate like structural elements.

[0009] FIG. **1** shows perspective views of devices having metal surfaces that can be treated with the coatings described herein.

[0010] FIG. **2** illustrates a cross-section view of a part having an anodic oxide coating.

[0011] FIGS. **3**A and **3**B illustrate cross-section views of a part having a diamond-like carbon coating.

[0012] FIGS. **4**A and **4**B show cross-section views of a part that includes an abrasion-resistant coating.

[0013] FIGS. **5**A-**5**D show cross-section views of portions of a part undergoing a process for applying an abrasion-resistant coating.

[0014] FIG. **6** shows an isometric cross-section view of a portion of a housing with an abrasion-resistant coating.

[0015] FIG. **7** shows a flowchart indicating a process for forming an abrasion-resistant coating.

DETAILED DESCRIPTION

[0016] Reference will now be made in detail to representative embodiments illustrated in the accompanying drawings. It should be understood that the following descriptions are not intended to limit the embodiments to one preferred embodiment. To the contrary, it is intended to cover alternatives, modifications, and equivalents as can be included within the spirit and scope of the described embodiments as defined by the appended claims.

[0017] Coatings that provide improved resistance to abrasion and denting are described. The coatings can include a hard outer layer and an intermediate metal oxide layer. The hard outer layer can be composed of a non-metallic and non-polymer material, such as a carbide, a nitride, a diamond-like carbon (DLC), or a hard metal oxide. The intermediate metal oxide layer can be positioned between the hard layer and a metal substrate so as to provide structural support for the hard layer. The intermediate metal oxide layer can be sufficiently hard to minimize plastic deformation during impact, thereby making the coating more resistant to abrasion, denting or incurring other defects that can cosmetically and structurally compromise the coating.

[0018] Processes for forming the abrasion-resistant coating can include an anodizing process and a deposition process. The anodizing process can be used to convert a portion of a metal substrate to a corresponding porous oxide layer. The anodizing conditions can be chosen to form an oxide layer with a desired hardness, pore size and thickness. The deposition process can be used to deposit a thinner hard material onto the oxide porous oxide layer. The hard material can be composed of a ceramic (e.g., nitride, oxide or carbide material) or other hard material such as diamond-like carbon (DLC) and can be deposited using any suitable technique, such as a physical vapor deposition process.

[0019] The abrasion-resistant coatings can also be used to provide a cosmetic quality to a part. For example, in some